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Survey of Recycled Nano Magnetic Particle in Benzene Removal from Aqueous Solution

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The removal of benzene, a hazardous monoaromatic compound, from aqueous solution by recycled nano magnetic particle (NM) Fe_3O_4 in batch condition was evaluated. Regeneration studies verified that the benzene adsorbed by the NM could be easily desorbed by temperature. So that the benzene removal efficiency was 98.7 % for raw NM, 97.8 % for first recycled NM and 97.4 percent for second recycled NM. It is expected that the Fe_3O_4 nanoparticles with fine grain size (20-30 nm) will be used as one of effective, convenient and low-costing methods for removal and recovery of benzene from water and wastewater.

Keywords: Nano magnetic particle, Regeneration, Benzene, Wastewater pollution.

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1. INTRODUCTION

Benzene is one of the air, surface water and groundwater contaminator. It is volatile monoaromatic compound originated from petroleum products [1, 2]. Epidemiological studies show its serious adverse effects to human health such as the diseases to the skin problems and sensory irritation, central nervous system depression, respiratory problems, leukemia, cancer, as well as disturbance of kidney, liver and blood systems) [3-5]. Benzene removal from aqueous solution has been widely studied in order to investigate a suitable method in different condition including bioremediation, volatilization, oxidation and adsorption [4-11]. The application of adsorption methods by using resins [12], raw and modified diatomite [5], organo-clays [13] and carbon nano tubes [14, 15] have been approved for benzene mitigation.

There are many studies that used of magnetic nano particle for environmental pollutants removal. But the most important problems about use of nano particles in water and wastewater treatment are the release and cost of them. Besides those techniques, the idea of benzene removal using magnetic column, which is being presented in this paper, might be a solution for contaminated water and wastewater treatment without adding new pollutants to the environment and reduce the cost.

The originality of this paper is using of continues condition in a magnetic column for preventive of nano particle release in effluent. On other hand it can be reduced the space and cost requirement for water and wastewater treatment.

2. MATERIALS AND METHODS

2.1 Materials

Benzene (purity 99 %) purged from Merck and and removed by NM (Fe_3O_4, 20-30 nm, APS, 98^+ % purity, ≥ 40 m^2/g SSA) from aqueous solution. The morphology of adsorbents was analyzed by transmission electron microscopy (TEM) Philips CM10-100KV and XRD pattern was obtained from X-Ray Diffractometer, Bruker, D8ADVANC.

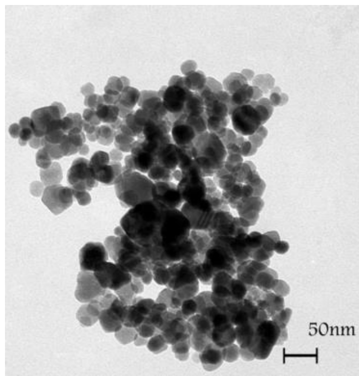

Fig. 1 – TEM image of NM

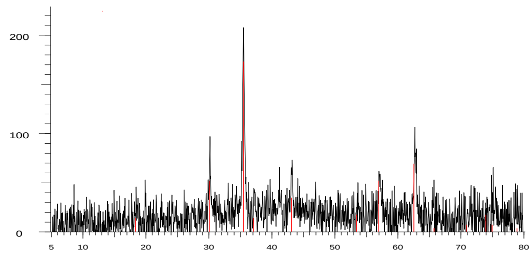

Fig. 2 – XRD image of NM

2.2 Experimental

Batch adsorption experiments were conducted using 110 ml glass bottles with addition of 100 mg of adsorbents and 100 ml of Banzene solution with concentrations (C_0) 100 mg/l. The glass bottles were sealed with 20 mm stopper. Headspace within each beaker was minimized to exclude any contaminant volatilization phenomena. The glass bottles of the batch experiments were placed on a shaker (Orbital Shaker Model OS625), and were stirred at 240 rpm for 14 min in room temperature. The solution samples were then settled for 2 min. The supernatant was used to determining Benzene in the liquid phase using GC / MS chromatog-

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raphy. All the experiments were repeated three times and only the mean values were reported.

The reversibility of sorbents that used for Benzene removal from aqueous solution was evaluated via 2 adsorptions followed by 2 desorption. Recycling was also conducted at 105 ± 2 °C in 24 h by oven (Memmert D-91126, Schwabach FRG). All samples were performed at least in triplicate.

Benzene concentrations were analyzed by Agilent Technologies system consisting of a 5975C Inert MSD with Triple Axis Detector equipped with a 7890A gas chromatograph with a split / splitless injector. A HP-5 ms column (30 m × 0.25 mm Id, 0.25 μm), was employed with helium (purity 99.995 %) as carrier gas at flow rate of 1 ml/min. Static headspace analysis was performed using a CTC PAL- Combi PAL headspace sampler.

3. RESULTS

Table 1 shows the benzene removal percent by NM, was recycled in the first cycle (NMrec1) and was recycled in the second cycle (NMrec2) in optimum condition. Fig. 2 compares raw NM with their recycling in cycles of 1 and 2.

Table 9 – Benzene removal by raw and recycled NM at optimum condition

Adsor-bent	Benzene		
	C0 (mg/l)	Ct (mg/l)	Removal Percent (%)
NMraw	100	1.4	98.7
NMrec1	100	2.2	97.8
NMrec2	100	2.6	97.4

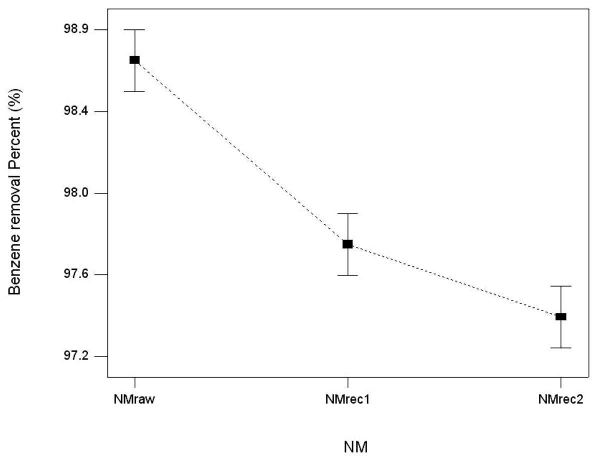

Fig. 2 – Design expert plot for raw and recycled NM in benzene removal at optimum condition

Although nano magnetic particle showed high benzene sorption capacities form aqueous solution, very high unit cost currently restricts their potential use in water treatment. Thus, testing the reversibility of sorbents that used for benzene removal is required in order to reduce their replacement cost. For this purpose as a part of the study, probability for used NM recycling was investigated. It should be highlighted that the major advantage that the magnetic separation offers is the ability to recover the nanoparticles and reused the particles for further benzene removal.

It is apparent from Fig. 8 that NM can be reused for the removal of benzene through a large number of water and wastewater treatment and regeneration cycles. But with increasing NM regeneration cycles, the benzene removal efficiency was decreased. There were statistics differences between raw NM, NMrec1, and NM rec2 in benzene removal percent (prob>t less than 0.05).

The results could hint that no strong bonds were created between the surface of NM and the benzene, so that the benzene adsorbed by the NM could be easily desorbed by temperature, and thereby NM can be employed repeatedly in water and wastewater management.

Shen et al. [16] were used of 0.1 M NaOH to regeneration of Fe_3O_4 that used for metal removal. They find that most of the adsorbed ions were desorbed in first cycle. This is the key factor for whether a novel but expensive sorbent can be accepted by the field or not. It is expected that the unit cost of NM can be further reduced in the future by recycling heat processes. So that, magnetic nanoparticles appear can be attractive as a cost-effective sorbent in removing benzene from the water and wastewater. The sorbent weight loss was neglected in the recycling processes.

4. CONCLUSION

After recycling of nanomaterials, NM was an efficient benzene sorbents and regenerated and reused in water and wastewater treatment works. But, heating may reduce adsorption capacity of recycled NM than raw NM. The application of magnetic nanoparticles for benzene removal and recovery of them provides a simple, but unique tool for benzene removal from water and wastewater. Benzene adsorption by new types of commercially available nano magnetic particle (Fe_3O_4) showed that this adsorbents to be reusable, cost-effective, and simple to use. It is expected that the Fe_3O_4 nanoparticles with fine grain size (20-30 nm) will be used as one of effective, convenient and low-costing methods for removal and recovery of benzene from water and wastewater.

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REFERENCES

1. X. Tang, Y. Xu, W. Shen, *Chem. Eng. J* **144**, 175 (2008).
2. A. Aly Hassan, G.A. Sorial, *J. Hazard. Mater.* **184**, 345 (2010).
3. D. Juretic, H. Kusic, N. Koprivanac, A. Loncaric Bozic, *Water Res.* **46**, 3074 (2012).
4. A. K. Mathur, C. B. Majumder, and S. Chatterjee, *J. Hazard. Mater.* **148**, 64 (2007).
5. M. Aivalioti, I. Vamvasakis, E. Gidarakos, *J. Hazard. Ma-*

ter. **178**, 136 (2010).
6. A. Changsuphan, M.I.B.A. Wahab, N.T. Kim Oanh, *Chem. Eng. J.*, **181-182** 215 (2012).
7. C. Long, Q. Li, Y. Li, Y. Liu, A. Li, Q. Zhang, *Chem. Eng. J.* **160**, 723 (2010).
8. H. Shim, E. Shin, S.-T. Yang, *Adv. Environ. Res.* **7**, 203 (2002).
9. C. Lu, F. Su, S. Hu, *Appl. Surf. Sci.* **254**, 7035 (2008).
10. M. Zhang, F. He, D. Zhao, X. Hao, *Water Res.* **45**, 2401 (2011).
11. A. Wagner, M. Cooper, S. Ferdi, J. Seifert, L. Adrian, *Environ. Sci. Tech.*, 46, 8960 (2012).
12. S.H. Lin, C.Y. Huang, *J. Hazard. Mater.* **70**, 21 (1999).
13. O. Carmody, R. Frost, Y. Xi, S. Kokot, *J. Colloid Interf. Sci.* **305**, 17 (2007).
14. B. Bina, H. Pourzamani, A. Rashidi, M.M. Amin, *JEPH*, **2012**, (2011).
15. H. Pourzamani, B. Bina, A. Rashidi, M. Amin, *IJEHE*, **1**, 4 (2012).
16. Y.F. Shen, J. Tang, Z.H. Nie, Y.D. Wang, Y. Ren, L. Zuo, *Biores. Techn.* **100**, 4139 (2009).